Advancing Nanomotion Sensor Technology to Provide Evidence for Active Life in Ocean Worlds

Completed Technology Project (2016 - 2018)

Project Introduction

One of the most pressing issues of ocean world exploration is the search for life. In this search, it could be argued that multiple lines of evidence are needed to build a case leading to the ultimate potential claim that life, indeed exists, or perhaps, existed in the past, on the planetary body or moon of interest. Thus, instrumentation is required to detect not only the molecular makeup of life based on chemistry, but also to provide evidence of morphological features of putative biological entities and to look for evidence of activity. Of these three, integrated layers of scientific information potentially working together to depict life, detecting activity is perhaps the most challenging. We propose a device that detects life in a chemistry independent manner. This apparatus uses a sensor that monitors nanometric scale motion to characterize living organisms. The device is inspired from atomic force microscopy (AFM) technology and consists of a 100 to 200 micometer long cantilever (sensor) and a motion detection system (laser and a multi-segment photodiode). Even the slightest movements of cells on the cantilever induce oscillations that modify the laser reflection angle and these movements are recorded. This very basic, and chemistry independent, life detection method was successfully tested on dozens of different bacteria types (motile and immobile, gram positive and negative, fast and slowly growing), and eukaryotic cells with always the same result - living organisms induce cantilever oscillations that stop when the organism dies. Similarly, it has been demonstrated that the oscillations not only reflect the dead/live state of the studied organism but also its metabolic state through collaboration with a team that uses these devices to rapidly assess bacterial sensitivity to antibiotics (in minutes instead of days or weeks as it is the case with traditional techniques). We are proposing to advance the technology in an ocean world-compatible framework so that it can become a potentially invaluable instrument of choice for life detection in Ocean Worlds targeted missions. Due to its intrinsic simplicity, light weight and chemistry independent operational principle we are convinced that this apparatus is well adapted to detect yet unknown life forms in extreme environments and fits well in the frame of the COLDTech program. There are six priority technology development activities we are proposing: 1. Develop prototype microfluidic systems and a sample collection system that can be automated for operations compatible with spacecraft science. 2. Design and develop nanomotion detector prototype to be compatible with an optical microscope. 3. Design strategy, concept and operation requirements for a dual function nanomotion detection-AFM imaging instrument. 4. Evaluate sample adhesion substances, determine optimal cellular-inactivation agents and experimental conditions. 5. Demonstrate life detection sensitivities with extremophile organisms and samples. 6. Ocean worlds analogue validation of protoype 2nd generation instrument. Together, this suite of technological advancements developed by teams from USA, Switzerland and Belgium positions nanomotion detection technology to be spacecraft compatible for ocean world life detection to support near term missions to ocean worlds. In addition, the design of a dual

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Organizational Responsibility

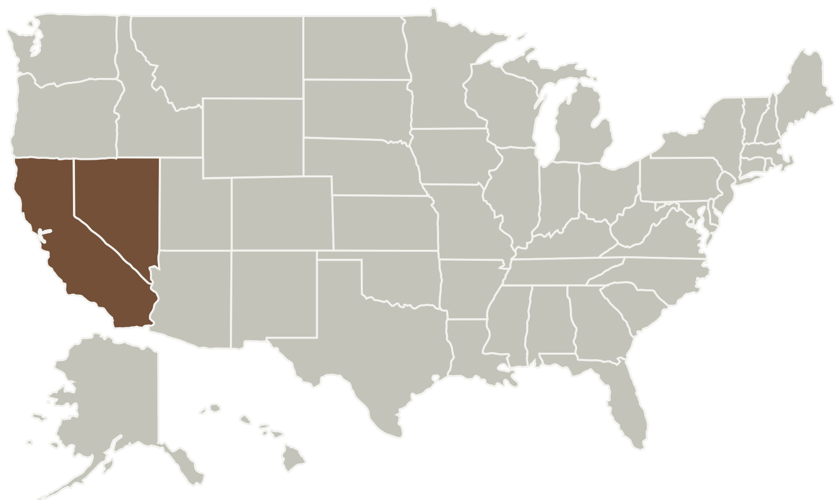
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Concepts for Ocean Worlds Life Detection Technology function life detection system which can both image samples and detect nanomotion may be invaluable for spaceflight optimization. The proposed effort will lead to an instrument that will provide evidence for the activity of life, compatible, but distinct from chemistry or microscopy-based approaches. Proof of concept science has demonstrated that this is a highly sensitive technology, and through the work proposed, this instrumentation will meet NASA's TRL level goals and be flight compatible in terms of specifications set out for light-weight payload missions, such as the Europa Lander.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Nevada System of Higher Education	Supporting Organization	Academia	Las Vegas, Nevada

Primary U.S. Work Locations	
California	Nevada

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Carolyn R Mercer

Principal Investigator:

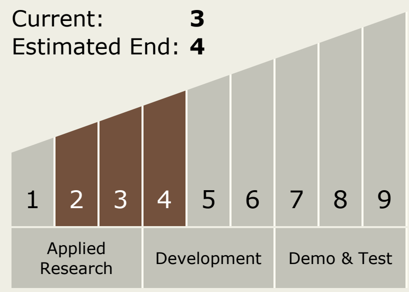
Alison E Murray

Co-Investigators:

Ronnie G Willaert
Petra Bartella
Tori M Hoehler
Giovanni Dietler
Ratrneshwar Lal
Sandor Kasas
Farooq Azam

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **4**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.3 In-Situ Instruments and Sensors

Continued on following page.

Technology Areas *(cont.)*

└ TX08.3.4 Environment Sensors

Target Destination

Others Inside the Solar System